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FATNESS IN GRENADIERS OF THE NORTH ATLANTIC

Fat accumulates in perches, minnows, herring-like fishes, and /97*
righteye flounders in the subcutaneous cellular tissue and in the internal organs, chiefly in the intestine; in cods and grenadiers the fat is concentrated in the liver. The behavior of the fishes depends on the quantity of fat accumulated in the liver [Konstantinov, 1967]. The cod, for example, having accumulated considerable fat in the liver, can remain in one place for a long time without feeding. M.A. Sonina [1969] notes a relationship between the fattening of the Barents Sea haddock and its migrations into the southeastern portions of the Barents Sea: haddock that possesses high fattiness does not form foraging stocks and remains concentrated in open water.

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*Translator's note: Numbers in the right-hand margin refer to the corresponding page in the Russian text.

Grenadier fishing began in the North Atlantic relatively recently (in 1967); the mode of life of these fish has not been adequately studied. A determination of the fatness of grenadiers aids in understanding and in predicting their behavior and the intensity of fattening in different seasons and in different years, as well as its periods of migration and spawning.

Liver is a valuable resource for canning, for medicinal fat, and for vitamins. We know that as early as the beginning of the nineteenth century Greenlanders caught the rouighhead grenadier, which they called the "imingoak," in deep fjords and consumed not only its meat, but its large liver as well [Jensen, 1948].

The annual catch of rock grenadier by the Soviet fleet in the North Atlantic amounts to tens of thousands of tons. The roughhead grenadier and the merlinspike are obtained as an incidental catch during trawling for cod, perch, and halibut, and statistical documents do not record them separately from the rock grenadier.

S.G. Podrazhanskaya and A.A. Yarzhombek [1970] have ascertained that the weight of the liver of the North Atlantic rock grenadier should be considered to be a more accurate indicator of the organism's /98
fat reserve than is the percentage fat content of the liver, and they proposed a formula for calculating the size of that reserve in g/kg of body weight ($x = 0.76y$, where y is the relative weight of the liver in g/kg). According to their data, the relative weight of the liver and its fat content, and therefore the body's fat reserve, is greater in the Atlantic grenadier than it is in the Baltic cod. The entire body of the grenadier, excluding the liver, contains only one gram of fatty

matter per kilogram of fish [Kleie, 1967]; consequently, the total fat reserve of the fish can be estimated from the weight of the liver.

The present work sums up the results of a study of the fatness of North Atlantic grenadier that are of commercial importance and that show commercial promise.

Material was collected between 1965 and 1978 from research vessels of PINRO and from exploration vessels of Northern Commercial Exploration in different regions of the North Atlantic. The fatness (relative weight of the liver) was determined for 20,845 specimens of rock grenadier, Coryphaenoides rupestris Gunn., for 1621 specimens of roughhead grenadier, Macrorus berglax Lacep., and for 384 specimens of marlinspike, Nezumia bairdii (Goode and Bean). The fish were weighed on a spring balance having an accuracy of up to 50 g and the liver on pan scales having an accuracy of up to 1 g.

The fatness curves and curves of relative composition are presented in smoothed form in Figure 1 and 3 to 7. The fit of the series was made according to the formula $B = a+2b+c/4$, where a, b, c are the antecedent, mean, and consequent members of the series, and B is the computed figure.

When comparing the average annual fatness of grenadier and the average water temperature in the 200-500 m layer at hydrological reference section 8-A, series of observations were selected between coordinates 54°26'N., 54°19'W. and 54°50'N. and 53°32'W. (section "B").

We know that in cod, which are similar to grenadier, the liver sometimes attains 22 percent of the body weight [L.P. and R.A. Minder, 1967]. The relative weight of the liver of the fish is not uniform in

the different regions, and it also varies from year to year and especially from season to season. Thus, for example, the fatness of haddock in the southern portion of the Barents Sea for the period from 1954 to 1956 varied between 3 percent in March, in a year of poor fattening, to 6 percent in July, with intensive fattening on capelin and euphausids [Sonina, 1967]. The grenadiers are similar to cods in this regard.

According to our data, the average fatness of North Atlantic rock grenadier between 1965 and 1978 amounted to 5.5 percent, based on 20,845 specimens (Table 1). The variation of fatness from year to year is rather considerable. Thus, in the region of Northern Labrador, /100 where the greatest quantity of fish was taken for analysis, their fatness amounted to 11.3 percent in 1969, while in 1971 it amounted to 5.6 percent. It is interesting to note that the fatness of grenadier in the Northwestern Atlantic is considerably greater than that of grenadier in the Northeastern Atlantic. Evidently in the latter region a portion of the fat reserve of the liver is expended during the maturation of genital products. E.F. Kleie [1967] notes that in the case of grenadier of the Far East, when the relative weight of the eggs increases, the relative weight of the liver diminishes along with its fat content, since fat reserves of the liver are expended during maturation of the gonads. This is also a feature of the North Atlantic rock grenadier. The fatness of rock grenadier caught in 1967 in the area off Iceland (post-spawning and sexually immature fish) amounted on average to 3.7 percent [Gritskevich et al., 1970].

Our research has shown that the relative weight of the liver of males and females diminishes as the fish mature sexually. Non-spawning

TABLE 1

The fatness of rock grenadier in different regions of the Atlantic for different months in the years 1965–1978, per cent:

Region of investigation	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1965–1978	Number of fish specimens
Baffin Land	----	----	5.7	6.1	6.4	5.7	6.0	----	5.4	6.5	----	----	----	----	6.1	2 057
Western Greenland	----	----	3.7	----	5.4	4.9	6.8	5.9	5.7	5.4	6.5	5.9	----	----	5.9	3 421
Northern Labrador	----	7.7	7.4	7.0	11.3	----	5.6	5.7	4.9	5.4	6.0	6.3	7.1	6.2	6.4	3 826
Central Labrador	6.5	----	8.0	----	8.8	----	8.4	----	----	8.1	8.2	11.1	----	----	8.4	964
Southern Labrador	----	----	5.6	----	----	----	----	----	----	----	7.2	7.3	----	7.9	6.5	703
Notre-Dame Bay	----	----	5.9	5.1	5.7	5.2	4.7	5.4	6.0	6.3	6.1	----	6.7	8.1	5.9	5 487
St John's region	----	----	----	----	----	----	----	----	----	----	----	----	6.6	----	6.6	30
Flemish Cape Bank	----	----	----	----	----	----	----	----	----	----	----	----	----	5.3	5.3	598
Brown's Bank	----	----	----	----	----	----	----	4.0	----	----	----	----	----	----	4.0	287
Reik'yanes Ridge*	----	----	----	----	----	----	----	----	3.9	4.8	3.6	3.9	----	----	3.7	2 302
Rokoll Bank*	----	----	----	----	----	1.8	----	----	----	3.4	----	----	----	----	2.8	191
Hatton Bank*	----	----	----	----	1.6	----	1.8	----	----	----	----	4.4	----	----	3.0	547
Porcupine Bank	----	----	----	----	----	----	----	----	----	----	2.7	----	----	----	2.7	100
Iceland region	----	----	5.0	----	----	----	3.6	----	----	----	----	----	----	----	4.5	332
All regions	6.5	7.7	5.9	6.2	6.2	4.9	4.9	5.6	5.2	6.0	4.2	5.5	6.8	6.1	5.5	
Number of fish specimens	100	300	1607	600	2008	649	2607	2599	1899	1841	1717	1515	1249	1154		20 845

*Translator's note: These names have been transliterated from the Russian, without attempting to give the English equivalent.

and post-spawning fish (gonad development stages V and VI) on the George Bleigh [?] and Hatton [?] banks, located southwest of the Faeroe Islands, are characterized by the lowest relative liver weight (see Figure 1). The fat contained in the meat is also expended. The content of fat in the meat of male rock grenadier at gonad development stages II-IV amounts to 0.94 to 0.97 percent and decreases sharply in males of gonad development stage V (to 0.14 percent). The fat content of the meat of post-spawning males increases to 0.61 to 0.71 percent.*

The fattening of many fishes occurs more intensively in /101 years of warmer water temperatures. Thus, for example, the relative weight of the liver and its fat content in cod and navaga [Eleginus navaga] of the White Sea are at their maximum in years with a relatively high water temperature [Makarova et al., 1971]. The rock grenadier inhabits the great depths, where year-to-year and seasonal variations in water temperature are less pronounced than in the upper layers of the ocean. Despite this, the thermal regime of the water clearly affects the intensity of this fish's fattening. A relationship has been demonstrated between the average annual fatness of the grenadier and the average water temperature in the 200-500 m layer at hydrological reference section 8-A (Figure 2). The water temperature in the 200-500 m layer in the main branch of the Labrador Current is characterized by the warm state of the water in the vicinity of the continental slope of Labrador and Newfoundland. Hydrological section 8-A takes measurements every year in November. The correlation coefficient between water temperature and grenadier fatness in the

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*Based on material presented to the author by Yu.F. Dvinin (Laboratory of the Biochemistry of Raw Material, PINRO).

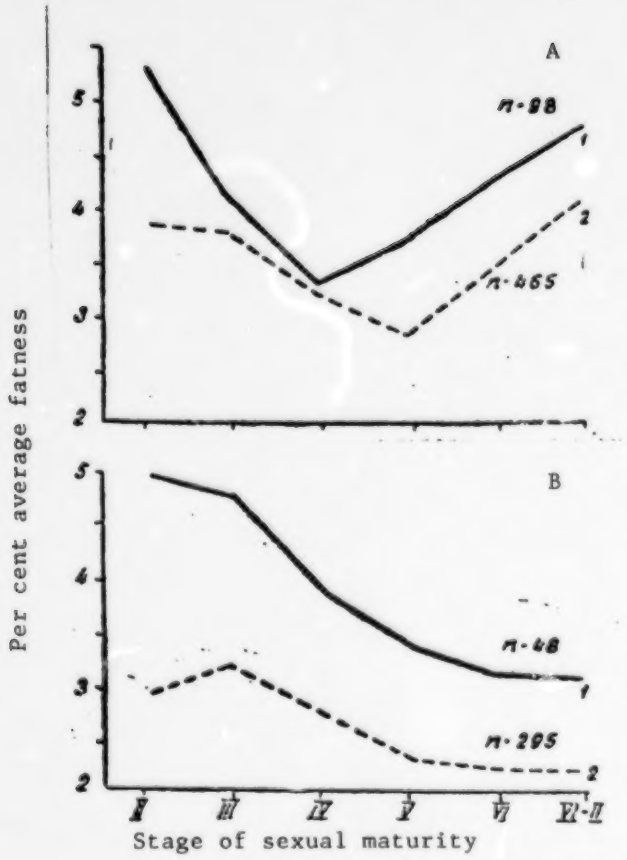

FIGURE 1

The average fatness of males (A) and females (B) of rock grenadier in different stages of sexual maturity at (1) George Bleigh [?] Bank in 1976 and at (2) Hatton [?] Bank in 1969, 1971, 1976, and 1979.

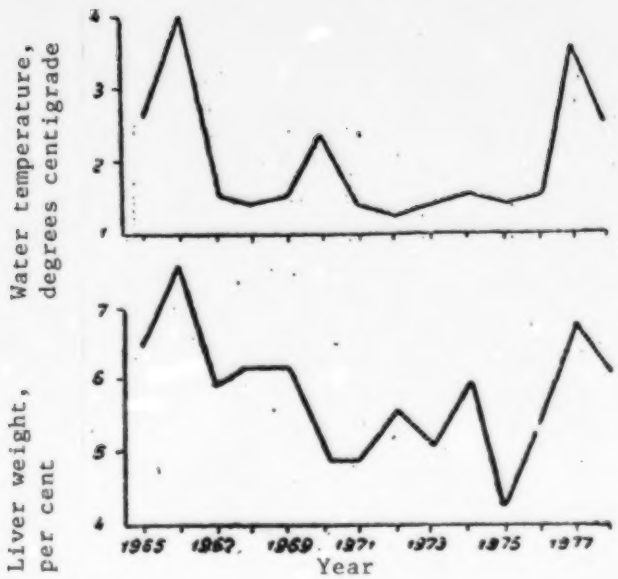

FIGURE 2

The average fatness of rock grenadier and the water temperature in November in the 200-500 m water layer in the main branch of the Labrador Current during the years 1965 through 1977.

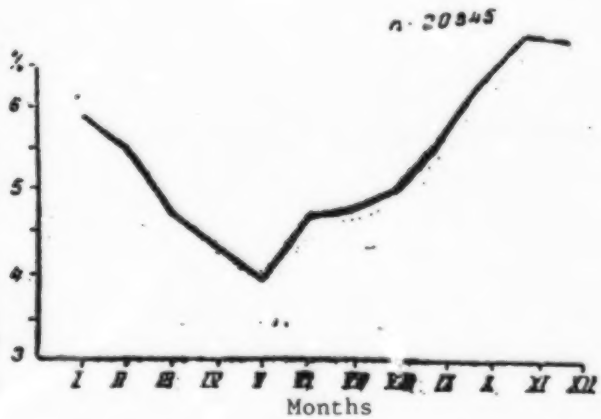

FIGURE 3

The fatness of the North Atlantic rock grenadier on average for different months in the period between 1965 and 1978.

TABLE 2

The average fatness P of rock grenadier and the average water temperature T in the 200–500 m water layer at hydrological reference section 8–A on November 1:

Year	P, %	T, °C.	Deviation from long-term average: P, %	T, °C.
1965	6.5	2.59	+ 0.7	+ 0.58
1966	7.7	3.97	+ 1.8	+ 1.96
1967	5.9	1.54	+ 0.1	- 0.47
1968	6.2	1.42	+ 0.4	- 0.59
1969	6.2	1.42	+ 0.4	- 0.50
1970	4.9	2.32	- 0.9	+ 0.31
1971	4.9	1.44	- 0.9	- 0.57
1972	5.6	1.26	- 0.2	- 0.75
1973	5.2	1.41	- 0.7	- 0.60
1974	6.0	1.59	+ 0.1	- 0.42
1975	4.2	1.45	- 1.6	- 0.56
1976	5.5	1.51	- 0.3	- 0.50
1977	6.8	3.62	+ 0.9	+ 1.61
1978	6.1	2.51	+ 0.2	+ 0.50
Average	5.8	2.01	0.0	0.0

TABLE 3

The fatness of rock grenadier in different regions of the Atlantic by month in the period 1965-1978, per cent:

Region of investigation	January	February	March	April	May	June	July	August	September	October	November	December	January through December	Number of fish specimens
Baffin Land	---	---	---	---	---	---	6.1	5.7	6.3	6.8	---	---	6.1	2 057
Western Greenland	---	---	---	---	4.1	6.3	5.7	5.3	5.7	7.1	5.7	7.0	5.9	3 421
Northern Labrador	---	---	---	---	---	---	5.7	6.9	6.0	6.9	6.5	6.4	6.4	3 826
Central Labrador	---	---	---	---	---	---	6.5	---	---	8.8	8.3	9.0	8.4	964
Southern Labrador	7.3	---	---	---	---	---	---	4.6	---	6.1	7.2	7.6	6.5	703
Notre-Dame Bay	6.0	5.5	7.1	---	4.8	5.1	5.5	5.9	---	5.0	6.0	7.5	5.9	5 487
St John's region	---	---	---	6.6	---	---	---	---	---	---	---	---	6.6	30
Flemish Cape Bank	---	5.0	5.3	---	---	---	---	---	---	---	---	---	5.3	598
Brown's Bank	---	---	---	---	4.0	---	---	---	---	---	---	---	4.0	287
Reik'yanes Ridge*	4.8	---	---	2.6	4.4	---	3.4	3.2	4.5	3.9	---	3.9	3.7	2 302
Rokoll Bank*	---	---	---	---	---	---	---	1.8	3.4	---	---	---	2.8	191
Hatton Bank*	---	---	---	1.6	---	---	4.6	1.8	4.3	---	---	---	3.0	547
Porcupine Bank	---	---	---	---	---	---	---	---	---	2.6	---	---	2.7	100
Iceland region	---	---	---	---	3.6	3.5	4.6	5.4	---	---	---	---	4.5	332
All regions	5.9	5.2	5.6	2.3	4.2	4.8	4.7	4.9	5.3	6.3	6.5	6.7	5.5	
Number of fish specimens	1414	200	572	159	552	492	2759	4334	3044	2600	2873	1846		20 845

*Translator's note: These names have been transliterated from Russian, without attempting to give the English equivalent.

period from 1965 to 1978 amounted to 0.7066±0.0896. In years with a low water temperature, the relative weight of the grenadier liver was less. In the unusually warm years 1966 and 1977 the grenadier displayed its greatest fatness (see Figure 2, Table 2).

It is difficult to follow the variation in grenadier fatness during the course of a particular year by individual region, since there is no one single region where such material could be collected for every month (Table 3). Nevertheless, the increase in the fatness of the fish on average for all regions occurs from summer to winter and decreases from spring to summer (see Figure 3). The lowest fatness (2.3 percent) was observed in April and the highest (6.5 to 6.7 percent) in November and December (see Table 3), which corresponds well with the change in the intensity of grenadier feeding during the course of the year. During the period of intensive fattening (summer and autumn), fat accumulates in the liver of the grenadiers and the weight of the liver increases. The low fatness of the grenadier in April is a consequence of poor fattening during the winter period. Relying on the previously presented formula [Podrazhanskaya and Yarzhombek, 1970], we find that the average fat reserve of the grenadier in April amounts to 17.43 g/kg, and in December to 50.92 g/kg of body weight, i.e. on average the fat reserve of the grenadier triples during the course of summer and autumn fattening.

In order to analyze the change in fatness as the fish grows and to explain whether or not there is a difference in fatness between males and females, we selected material from the primary fishing regions (Subregion IKNAF 0 and 1 and microregions 2G and 3K), from which the most complete samples were taken. The fish were distributed

TABLE 4

The average fatness of male and female rock grenadier by month for the period from 1966 to 1978 in per cent, as a total for the regions of Northern Labrador and Notre-Dame Bay, the subregions of Western Greenland and Baffin Land, and in the microregions; length in centimeters:

Month	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91-100	Ave.*	Number of fish specimens
					MALES						
January	---	---	6.0	7.2	6.9	6.7	6.3	6.1	3.4	6.6	721
February	---	---	6.2	5.8	6.1	5.5	6.7	6.0	---	6.1	56
March	---	---	---	---	9.5	7.8	6.6	10.3	---	8.0	38
April	---	---	---	---	---	---	---	---	---	---	-
May	---	---	5.2	4.2	4.4	6.5	5.1	---	---	4.9	73
June	---	---	9.5	9.1	7.4	5.7	6.8	---	---	6.8	51
July	---	4.6	5.0	6.3	6.1	6.4	6.1	5.1	---	6.2	989
August	---	6.5	4.9	5.6	5.7	6.1	6.3	6.7	5.5	6.0	2 262
September	6.9	9.9	8.4	7.1	6.6	6.6	6.4	6.0	5.5	6.6	1 473
October	---	6.7	4.8	6.6	6.9	6.9	7.5	8.1	5.5	7.1	1 399
November	---	---	5.6	5.5	6.3	6.4	7.2	6.7	---	6.6	1 360
December	6.2	5.5	7.1	7.5	7.5	7.6	7.7	11.3	---	7.6	602
Jan.-Dec.	6.5	6.2	6.1	6.2	6.4	6.6	6.8	6.6	5.1	6.6	
Specimens	3	44	353	1180	2719	3038	1511	171	5		9 024
					FEMALES						
January	---	---	6.7	6.0	5.6	5.2	4.9	4.7	8.0	5.2	487
February	---	---	4.0	4.1	5.1	5.0	4.1	6.2	---	4.7	44
March	---	---	---	---	6.0	6.2	6.0	5.7	---	6.1	36
April	---	---	---	---	---	---	---	---	---	---	-
May	---	---	1.5	3.8	4.3	5.9	3.6	---	---	4.3	50
June	---	---	8.8	6.8	6.6	4.8	5.0	---	---	5.8	49
July	---	4.5	4.5	5.6	5.0	5.2	4.9	4.6	2.2	5.0	667
August	---	5.0	4.3	4.8	4.7	5.6	5.6	5.6	4.3	5.4	1 200
September	2.9	8.2	6.8	5.6	5.2	4.8	4.8	5.2	3.7	5.0	830
October	---	1.5	6.4	5.7	5.6	5.6	4.7	6.2	6.3	5.4	700
November	10.0	9.2	6.2	4.9	5.0	5.4	5.8	6.0	5.9	5.6	813
December	---	6.3	6.3	7.2	6.3	6.6	6.4	7.0	---	6.5	380
Jan.-Dec.	5.7	5.5	5.3	5.4	5.2	5.5	5.2	5.5	4.7	5.7	
Specimens	4	32	221	625	1360	1692	1044	246	12**		5 256

Translator's notes: *I have interpreted this column as the average for all size classes (see top page 12); the Russian gives 11-100 (see over).

**I have shifted this figure over one column on the assumption made in my previous note. See next page for original Russian table.

Таблица 4

Средняя жирность самцов и самок тупорылого макруруса суммарно в подрайонах Западная Гренландия и Баффинова Земля, микрорайонах Северный Лабрадор и Залив Нотр-Дам по месяцам за 1966—1978 гг., %

Месяц	Length of males Длина самцов, см										Количество рыб, экз.	Length of females Длина самок, см										Количество рыб, экз.
	11—20	21—30	31—40	41—50	51—60	61—70	71—80	81—90	91—100	—11 100		11—20	21—30	31—40	41—50	51—60	61—70	71—80	81—90	91—100	11—100	
Jan. Январь	—	—	6,0	7,2	6,9	6,7	6,3	6,1	3,4	6,6	721	—	—	6,7	6,0	5,6	5,2	4,9	4,7	8,0	5,2	487
Feb Февраль	—	—	6,2	5,8	6,1	5,5	6,7	6,0	—	6,1	56	—	—	4,0	4,1	5,1	5,0	4,1	6,2	—	4,7	44
Mar Март	—	—	—	—	9,5	7,8	6,6	10,3	—	8,0	38	—	—	—	—	6,0	6,2	6,0	5,7	—	6,1	36
Apr Апрель	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
May Май	—	—	5,2	4,2	4,4	6,5	5,1	—	—	4,9	73	—	—	1,5	3,8	4,3	5,9	3,6	—	—	4,3	50
Jun. Июнь	—	—	9,5	9,1	7,4	5,7	6,8	—	—	6,8	51	—	—	8,8	6,8	6,6	4,8	5,0	—	—	5,8	49
Jul Июль	—	4,6	5,0	6,3	6,1	6,4	6,1	5,1	—	6,2	989	—	4,5	4,5	5,6	5,0	5,2	4,9	4,6	2,2	5,0	667
Aug Август	—	6,5	4,9	5,6	5,7	6,1	6,3	6,7	5,5	6,0	2262	—	5,0	4,3	4,8	4,7	5,6	5,6	5,6	4,3	5,4	1200
Sep Сентябрь	6,9	9,9	8,4	7,1	6,6	6,6	6,4	6,0	5,5	6,6	1473	2,9	8,2	6,8	5,6	5,2	4,8	4,8	5,2	3,7	5,0	830
Oct Октябрь	—	6,7	4,8	6,6	6,9	6,9	7,5	8,1	5,5	7,1	1299	—	1,5	6,4	5,7	5,6	5,6	4,7	6,2	6,3	5,4	700
Nov Ноябрь	—	—	5,6	5,5	6,3	6,4	7,2	6,7	—	6,6	1360	10,0	9,2	6,2	4,9	5,0	5,4	5,8	6,0	5,9	5,6	813
Dec Декабрь	6,2	5,5	7,1	7,5	7,5	7,6	7,7	11,3	—	7,6	602	—	6,3	6,3	7,2	6,3	6,6	6,4	7,0	—	6,5	380
January-December Январь—декабрь	6,5	6,2	6,1	6,2	6,4	6,6	6,8	6,6	5,1	6,6		5,7	5,5	5,3	5,4	5,2	5,5	5,2	5,5	4,7	5,7	
Количество рыб, экз.	3	44	353	1180	2719	3038	1511	171	5		9024	4	32	221	625	1360	1692	1044	246		12	5256

Translator's note: This is the original Table 4 from the Russian text. I have indicated the alterations that I made in transposing the table into English in red. I have made two changes: (1) I have changed the column marked "11–100" under females and "–11 100" under males to "Ave." (to agree with the statement on average fatness made in the last line of the top paragraph on page 12), and (2) I have moved the figure "12" one column to the left.

into classes by length intervals of 10 cm: 11-20, 21-30, etc. The fatness of the grenadier in general increases with an increase in the length of the fish, particularly in males, but this occurs unevenly (Table 4). Fatness is somewhat greater in fish with a length of 11-20 cm than it is in fish of subsequent length classes. Fish with a length of 31-40 cm possess the lowest fatness. The fatness of males in /104
all length classes is greater than that of females. On average the fatness of males amounted to 6.6 percent and that of females to 5.7 percent.

The tendency for fatness to increase with an increase in the size of the rock grenadier is of special practical interest. If we take into consideration the high value of the grenadier liver, than fishing should be oriented towards fish of larger sizes. Large fish, moreover, are processed more readily and they provide a greater yield of final product. This once again confirms the advisability of developing deep-sea fishing, since the number of large fish in the catch increases with depth. Thus, in the vicinity of Notre Dame Bay in June 1968, the average length of grenadier in catches by BRMT-417 [BRMT: Soviet designation for a large refrigerated fishing trawler] was 48.8 cm at depths of 660-780 m, while it was 58.5 cm at depths of 800-1040 m (see Figure 4). In this same area in January 1981 an increase in the size composition of the fish catch as depth increased was again recorded.

The literature contains almost no information on the fatness of other species of Atlantic grenadiers. The fatness of the roughhead grenadier, which was studied by L.P. Minder [1967], attains 16 percent (an average of 8.6). According to Polish researchers [Nodzynski and

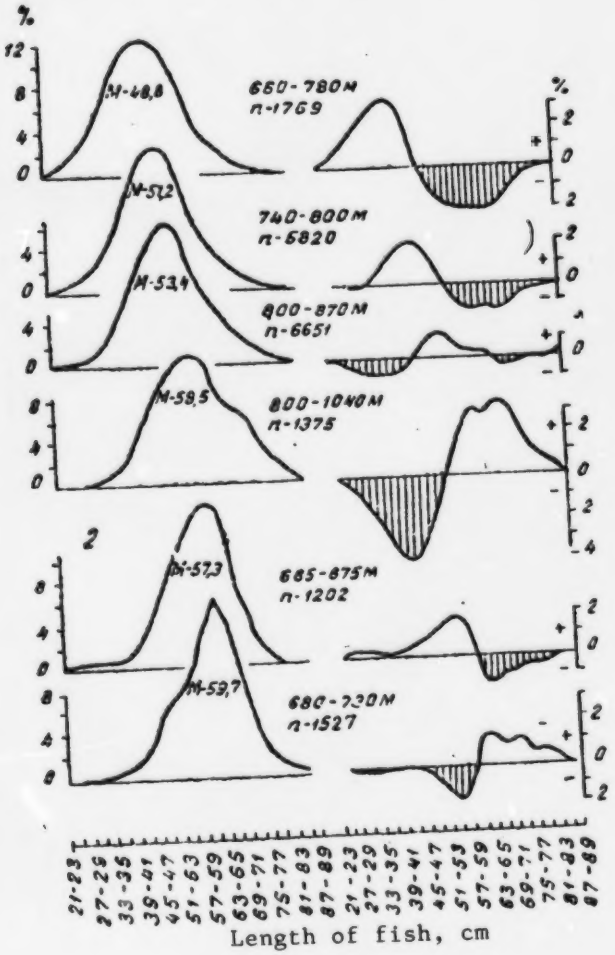

FIGURE 4

The size composition of rock grenadier at various depths in bottom trawling catches in the Notre-Dame Bay microregion:

1 : June 12-21, 1968;

2 : January 30-31, 1981;

M : average length.

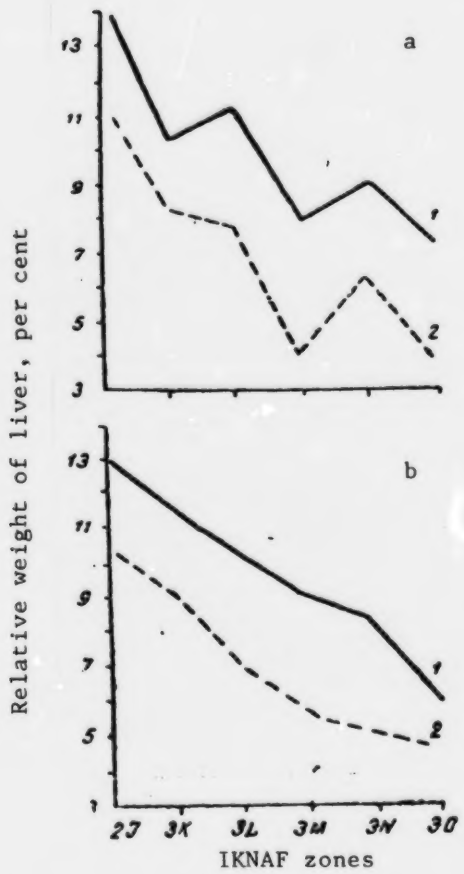

FIGURE 5

The average fatness of (1) male and (2) female rock grenadier in the period from 1969 to 1978 (a) in different microregions and (b) the fatness, in smoothed form.

TABLE 5

Fatness of the roughhead grenadier by month in the 1969–1979 period; the figure above the bar indicates the fatness in per cent, and the figure below the bar indicates the number of fish:

Month, year	Microregion of investigation					
	2J	3K	3L	3N	3M	3O
February, 1978	—	—	—	—	5,2 / 181	—
March, 1976	—	—	12,4 / 99	—	—	—
May, 1974	—	11,0 / 99	—	—	—	—
May, 1977	—	—	7,9 / 73	5,1 / 35	—	—
June, 1971	—	—	—	6,8 / 189	—	—
June, 1977	—	—	7,6 / 74	—	—	—
July, 1977	—	6,9 / 21	—	—	—	—
July, 1978	11,1 / 70	—	—	—	—	—
August, 1978	—	—	—	8,2 / 50	—	—
September, 1969	—	—	5,8 / 197	4,7 / 93	8,0 / 63	—
October, 1969	—	—	—	—	—	5,2 / 57
November, 1969	12,2 / 71	—	—	—	—	—
November, 1975	—	—	8,6 / 100	—	—	—
November, 1979	—	6,7 / 149	—	—	—	—
February – November, 1969 – 1979	11,9 / 141	8,7 / 269	8,9 / 543	6,6 / 367	5,9 / 244	5,2 / 57

TABLE 6

The fatness of roughhead grenadier of different length classes in the Northwestern Atlantic; totals for 1969-1979, in per cent:

Fish length, cm	MALES						FEMALES						MALES	FEMALES	MALES & FEMALES
	2J	3K	3L	3M	3N	3O	2J	3K	3L	3M	3N	3O	All microregions		
15—17	—	—	—	—	—	—	—	—	3,0	—	—	—	—	3,0	3,0
18—20	—	—	—	—	—	—	6,0	4,6	1,7	—	—	—	—	3,3	3,3
21—23	—	3,3	3,8	—	1,7	—	—	—	3,4	—	3,9	—	3,4	3,6	3,5
24—26	6,2	2,1	2,3	—	2,3	—	—	3,9	2,7	3,6	4,3	—	3,1	2,6	3,4
27—29	6,6	4,9	3,9	2,7	4,5	—	6,6	3,5	2,9	2,4	5,5	—	4,4	3,5	3,9
30—32	—	4,9	4,4	3,7	—	4,2	5,4	3,9	4,2	2,9	4,2	—	4,5	4,1	4,2
33—35	9,5	4,5	4,7	4,2	—	4,8	9,6	4,4	8,2	3,9	3,7	3,3	4,9	7,5	6,2
36—38	10,6	3,8	6,9	4,6	3,4	3,6	—	4,6	5,2	3,6	5,4	2,0	6,1	4,8	5,6
39—41	11,1	6,0	7,2	5,2	4,9	—	6,1	5,2	4,7	3,8	4,0	4,3	6,5	4,5	5,7
42—44	11,1	7,1	7,6	6,9	6,4	6,6	9,6	4,6	4,7	4,0	3,5	2,7	7,4	4,6	6,1
45—47	15,8	5,0	8,9	6,9	7,4	—	9,5	6,6	5,1	5,9	4,5	3,2	9,1	5,5	7,5
48—50	13,7	10,6	12,6	8,2	9,2	8,6	10,2	7,0	5,0	3,2	6,4	3,0	10,8	6,1	9,0
51—53	17,8	12,6	15,1	9,9	10,6	3,5	9,9	6,4	6,1	4,4	5,5	6,5	13,2	6,3	9,4
54—56	19,3	14,2	17,6	11,7	12,2	6,4	11,7	8,0	6,5	2,8	4,8	4,2	14,0	6,7	8,8
57—59	11,8	—	15,0	15,2	17,8	—	11,8	9,4	8,1	3,5	5,3	2,9	15,1	7,3	8,2
60—62	—	—	—	9,2	2,7	—	12,7	8,2	8,3	5,6	6,8	4,2	5,7	8,0	8,0
63—65	—	15,0	—	—	6,6	—	5,3	10,1	7,8	4,3	6,1	—	9,6	7,6	7,7
66—68	—	—	—	—	—	—	12,5	8,6	11,6	3,6	6,9	2,8	—	8,0	8,0
69—71	—	—	—	3,0	—	—	16,4	9,6	8,1	6,9	8,4	—	3,0	9,4	9,1
72—74	—	—	—	—	—	—	11,5	8,9	9,6	—	4,0	—	—	8,6	8,6
75—77	—	—	—	—	—	—	10,0	1,6	12,7	—	5,8	—	—	7,5	7,5
78—80	—	—	—	—	—	—	—	1,8	8,5	3,1	8,8	—	—	6,4	6,4
81—83	—	—	—	—	—	—	9,2	12,1	12,3	5,4	—	—	7,4	4,5	6,0
84—86	—	—	—	7,4	—	—	—	—	4,5	—	—	—	10,0	7,3	8,0
15—86	14,5	10,3	11,1	7,9	8,9	7,2	11,3	8,2	7,7	4,1	6,3	3,9	—	10,3	10,3
Number of fish	40	108	254	132	81	25	101	161	289	112	286	32	640	981	1621

TABLE 7

The length and the relative numbers of male and female roughhead grenadier at different stages of maturity in the regions of Southern Labrador and Newfoundland in the period 1969-1978:

Stage of maturity	Length of males, cm		Quantity of fish		Length of females, cm		Quantity of fish	
	range	average	number	%	range	average	number	%
I	21—44	33,0	29	3,8	15—47	31,6	17	1,2
II	21—65	44,6	624	81,1	18—80	52,4	1171	85,4
III	36—86	50,6	85	11,0	45—95	69,0	87	6,3
IV	57—65	60,1	3	0,4	63—80	71,8	7	0,5
V	39—59	52,1	6	0,8	—	—	—	—
VI	42—59	49,2	22	2,9	—	61,1	1	0,1
VI—II	—	—	—	—	39—83	63,0	89	6,5
TOTAL	21—86	45,2	769	100,0	15—95	54,0	1372	100,0

Zukowski, 1971], the fatness of the roughhead grenadier amounted to between 8.76 and 14.89 percent. Our data shows that the average fatness of roughhead grenadier which were caught between 1969 and 1978 in the regions of Newfoundland and Southern Labrador varied from 5.1 to 12.4 percent (Table 5). The average fatness based on all samples (1621 specimens) amounted to 8 percent, which is to say that it was greater than for the rock grenadier. The average fatness of grenadier from Southern Labrador and Notre Dame Bay was considerably greater than it was in the zones further to the south (see Tables 5 and 6 and Figure 5).

The average fatness of males from all samples amounted to 10 percent, that of females to 7.3 percent. The fatness of males and females varies unevenly with changes in their length (see Figure 6), because of fattening and the sexual maturation of the fish. The males /106
first achieve sexual maturity (maturity stage III) at a length of approximately 40 cm, while the great majority mature and participate in spawning when their length is 50-60 cm (Table 7). By this time they possess the highest relative liver weight (14 percent on average). As the fish continue to increase in length, the relative weight of the liver drops sharply and at a length of 69-71 cm it amounts to a total of only 3 percent. Roughhead grenadier females mature later than do the males, and they participate in spawning when their length is /107
60-70 cm (Table 7). The fatness of the females gradually increases until they reach that length.

Material on the marlinspike was collected only in September and October 1969 in the region of Newfoundland. The average fatness of the marlinspike, based on all samples (385 specimens), amounted to 9.1 percent, which is greater than in the other Macruridae that we

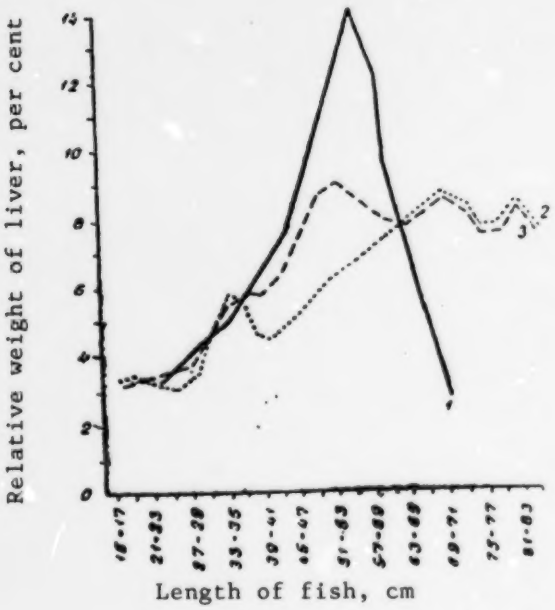

FIGURE 6

The average fatness of the roughhead grenadier of varying length in the Northwestern Atlantic:

1 : males;

2 : females;

3 : males and females.

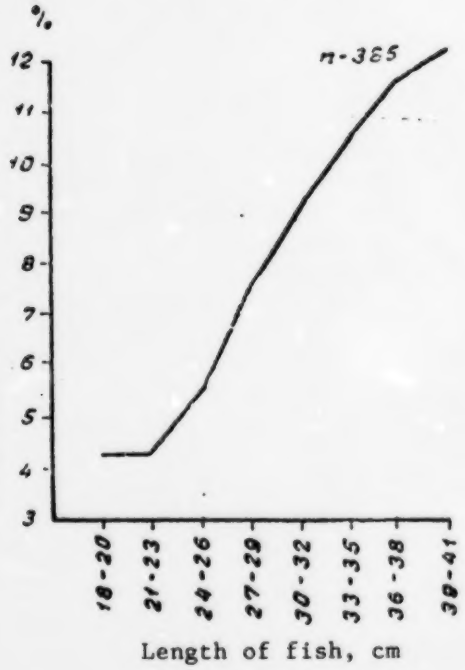

FIGURE 7

The average fatness of the marlinspike in the Newfoundland and Labrador sub-regions in September and October of 1969.

TABLE 8

The fatness of the marlinspike in the Newfoundland region in September and October of 1969, in per cent:

Micro-region	Sex	Length of fish, cm									Number of fish
		18—20	21—23	24—26	27—29	30—3	33—35	36—38	39—41	13—41	
3L	Males	—	3,8	4,3	6,0	10,1	11,8	—	—	8,0	13
3N	Males	—	—	7,9	14,9	—	12,6	—	—	12,9	4
3O	Males	—	4,2	4,2	8,6	8,1	2,5	—	—	6,6	39
3P	Males	—	4,0	5,9	9,9	10,0	—	—	—	8,8	60
3L	Females	—	—	—	—	—	7,7	8,6	—	8,4	8
3N	Females	—	—	—	—	3,3	10,4	13,1	—	10,4	9
3O	Females	2,9	3,3	5,0	5,4	6,3	7,9	16,1	9,2	7,0	69
3P	Females	5,9	3,8	4,6	7,0	10,2	11,8	12,5	13,7	10,2	183
All microregions	Males	—	4,0	5,1	9,4	9,5	9,4	—	—	8,2	116
	Females	4,5	3,6	4,7	6,5	9,1	10,6	11,5	12,1	9,4	269
	Males and females	4,5	3,8	5,0	7,9	9,2	10,5	11,5	12,1	9,1	385
Number of fish		8	19	51	110	94	82	18	3	385	

investigated (Table 8). Interestingly enough, the average fatness of the females (9.4 percent) proved to be greater than that of the males (8.2 percent), in contrast to the rock and roughhead grenadiers. Both in the males and in the females, the fatness of the marlinspike increases sharply with an increase in their length. The fatness was approximately 4 percent in fish with a length of 18-23 cm, while it was 12 percent in those 39-41 cm long (see Figure 7).

CONCLUSIONS

The fat in grenadier is concentrated in the liver. The highest fatness (relative liver weight) characterizes the marlinspike (9.1 percent on average), and less fatness characterizes the roughhead grenadier (8 percent) and the rock grenadier (5.5 percent). The fatness of males is greater than that of females for both the roughhead and rock grenadiers, as opposed to the marlinspike.

The fatness of grenadiers decreases with increasing maturity, since the fat reserves of the liver are expended during maturation of the genital products. Spawning and post-spawning fish have the lowest fatness.

The thermal regime of the water and, evidently, the state of the food supply related to it, determines fattening and the accumulation of fat in the liver of the rock grenadier. In years when the water temperature in the main branch of the Labrador Current was low, the fatness of the fish was not high, while in the unusually warm years of 1966 and 1977 it was at its highest.

The lowest fatness of the rock grenadier (2.3 percent on average) was recorded in April, and the highest (6.5-6.7 percent) in

November and December. The average fat reserve of the grenadier in April was 17.43 g/kg of body weight, while in December it was 50.92 g/kg. Consequently, it is advisable to conduct fishing operations in the autumn and winter period, when the fatness of the grenadier is highest.

The fatness of the grenadier increases as its length increases. The larger rock grenadier remain at greater depths, which makes it advisable to develop deep-water fishing. During processing, the larger fish provide a greater yield of final products (trunk, fillet, and liver).

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